Petroleum

My men can eat their belts,

but my tanks gotta have gas.

Attributed to George Patton

BEGINNINGS

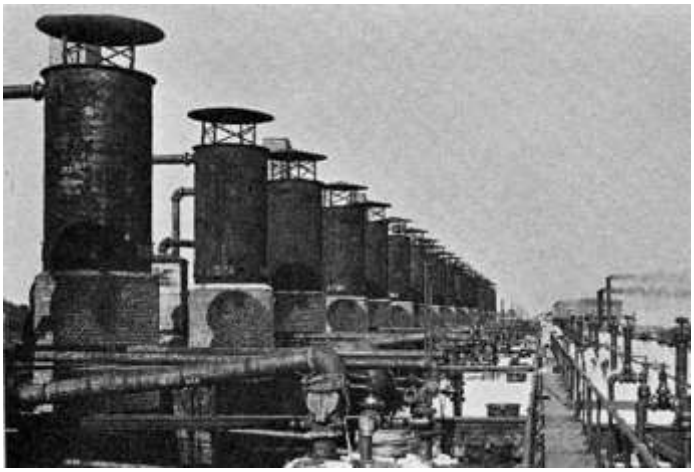
In 1847 a Scottish chemist discovered a way to distill a thick black liquid into useful products, including kerosene for lamps, paraffin for candles and grease. The petroleum industry began.

The success of these adventures provided an inexpensive new fuel, largely for lighting homes.

In the United States, Edwin Drake drilled the first deep well in Western Pennsylvania in 1859.

REFINING PETROLEUM

The refining process is the key to transforming raw petroleum into a variety of useful products. Petroleum is heated to a gaseous form in a tower like-structure.



The lighter grades will rise to the top and the heavier grades will remain at the bottom. From there the various grades of product can be extracted and cooled back to a liquid form.

Although petroleum refining has improved steadily since 1847, the basic concept has remained the same.

THE AUTOMOBILE

Refined petroleum products enabled development of an engine that burned the fuel inside the cylinder in the late 19th century, which became the internal combustion engine.

Between 1885 and 1890, several German engineers independently found ways to mount a gasoline engine on a frame, making primitive automobiles. By the early 20th century, the automobile showed promise of being a practical form of transportation.

The diesel engine first appeared about 1900; but it would be decades before one could be built small enough for any vehicle.

The Army & Motor Vehicles

The Army purchased its first automobile in 1903 and its first truck in 1907 despite doubts about their usefulness during the early years. By 1913 the Quartermaster Corps began developing specifications for Army trucks in anticipation of the greater use of trucks for the Army.

The turning point for motor vehicles came in 1916, when American cavalry forces entered Mexico to stop cross border raids.

Trucks proved their usefulness for transporting supplies, and sometimes Soldiers, over long distances. They extended the operational reach of the Army farther than anyone previously believed possible.

Motor transportation was here to say, and petroleum would be a necessary part of that story.

World War I

World War I moved petroleum into the logistical picture. Although trucks did not replace horses and mules, they proved to be more efficient at moving the massive quantities of supplies necessary to sustain the armies. Now armies could not function without trucks, and trucks could not work without fuel.

Other new systems also required fuel during this war. Near the end of the war the field artillery experimented with caterpillar type tractors to pull the heavy pieces. Fuel consumption for this effort was negligible, but it marked the beginning of the transition from horses to motorized transportation for artillery.

Tanks

Seeking a way to break through enemy trenches, the British introduced the tank in early 1917. The first large scale use of tanks came with the Battle of Cambrai from September through November 1917. these were huge (28-ton) machines, and prone to frequent breakdowns.

The French soon followed with a lighter Renault FT tank, which was widely used throughout the war. The Americans adopted both the French and the British versions.

By World War II the tank would multiply the consumption of petroleum in many ways. The tank in itself consumed and enormous amount of petroleum just to function in combat. Also the logistical tail required to keep it operating required fuel.

Until the 1960s most tanks used gasoline. The Diesel engine was not yet ready for vehicles.

Distribution

The French preferred to use the 50-liter cans (about 13 gallons) for distributing petroleum. These cans could be filled at base depots and then distributed on any form of transportation.

Americans preferred to use a combination of bulk distribution and the can method. Bulk distribution avoided the problems of providing enough cans and eased the congestion at transportation facilities.

At first the American high command forbade the use of bulk distribution near the front. Then in July 1918, the French and Americans launched a counteroffensive at Château-Thierry. In this crisis the French could not provide enough cans to supply both armies. At that point the American command relented and allowed a combination of cans and bulk distribution for the rest of the war.

After the war

Like virtually every other aspect of the Army, petroleum operations received negligible funding between 1919 and 1940. Responsibility for purchasing petroleum was split among the various staff agencies that used the material. The Quartermaster Corps used petroleum primarily for installation support, along with coal. There was little thought to the problems of distributing massive amounts of petroleum in the next major conflict.

Armored warfare, which had shown promise during World War I, was also neglected as the Army declined to develop new tanks, or doctrine for employing the new weapons.

Even as the Army was neglecting modernization and new technologies, developments in the civilian world ensured that the next war would consume unprecedented amounts of fuel. The automobile, truck, airplane, and internal combustion engine all continued to improve, with potential military applications. When Germany began to re-arm under the Nazi regime, they incorporated armored warfare and air power into their mix of weapons.

A New Form of War

In August 1940 Nazi Germany ran over France in a rapid advance that would be known as blitzkrieg, or lightning war. In response the US Army began a period of mobilization and restructuring to prepare for the possibility of war. This effort included a fresh look at mechanized warfare.

In comparison to future years, petroleum consumption per Soldier was relatively small during World War II. Most Soldiers still served in infantry units. At the time, however, this represented a dynamic shift to reliance on all the machines powered by internal combustion engines.

World War II Distribution

The US Army used a combination of bulk distribution and containers for supporting the ground forces. Specific methods varied depending on the situation.

The preferred method was to unload ships into storage tanks and move the fuel forward through either pipelines or tanker trucks. At some point the fuel was moved to smaller containers (5 gallon cans in Europe) for retail distribution.

As expected each situation presented its own challenges and solutions. During the early phases of any amphibious operation, the Army depended on containers to resupply fuel.

In the Pacific the nature of the logistics often dictated the use of 55-gallon drums instead of other methods. Similarly, lack of tanker trucks might increase the use of containers for moving the product.

In the Pacific

Petroleum in the Pacific presented many new and different challenges. Military operations spanned different islands, usually without the infrastructure to assist with petroleum.

The United States pooled petroleum facilities with Australia and New Zealand, operated base facilities in those nations and in Hawaii.

Here the Americans relied very heavily upon the 55-gallon drums to move petroleum. The infrastructure for bulk petroleum didn't exist.

The tropical climate also increased the deterioration of the product.

Europe

The critical importance of petroleum received its most dramatic demonstration in the halt of the Allied advance in the autumn of 1944. The allies advanced so quickly that the supply lines could not keep up.

As a result the advance lost its momentum, and extended the duration of the war. This has become the classic case of a logistical breakdown that affected the operational result.

The Army used a combination of means for moving petroleum. The Corps of Engineers constructed a pipeline that extended from Cherbourg into France. Tanker trucks moved bulk petroleum when available. The 5-gallon can remained the standard means of retail distribution.

Shortage of cans

In Europe the 5 gallon can was the principal means of retail distribution, and often used for transporting fuel. In theory each empty can was expected to be returned to the system for refill. In practice these cans tended to disappear.

Between June 6, 1944 and February 28, 1945 the Army in Europe lost approximately 70 percent of its 5-gallon cans (or 23 million cans out of a total of 32 million were lost).

Efforts to encourage turn in were only partially successful. Eventually arguments about distribution of these cans reached the ministerial level.

Pipelines

Before World War II petroleum pipelines were of limited use, even within the civilian sector. They required heavy pipes that were welded together in a laborious process to prevent leaks. They were primarily used for short distances in and around the refineries.

Beginning in 1941 the Quartermaster Corps expressed an interest in short distance pipelines near terminals and large fixed storage facilities. After brief experiments at the Holabird Depot in Baltimore, the Quartermaster Corps lost interest in pipelines. They considered pipelines only useful for moving petroleum from ports to distributions points over distances of five miles or less.

At this point the Corps of Engineers expressed an interest in longer petroleum pipelines that could replace railroads and trucks. The Engineers began experimenting with a 16-mile pipeline in Shenandoah National Park, and the success of this effort inspired greater work.

Burma Road

The first effort to create a military pipeline came as an effort to supply the Chinese forces in their fight against Japan. The Chinese had been driven from the coast, well into the interior. The only way to reach them came through a jungle road from India to China, known as the Burma Road. The US attempted to build a pipeline from India to China in order to spare the vehicle traffic.

In order to construct the pipeline the Engineers needed to solve technical problems, including coordinating the pressure on the mountain terrain and synchronizing the pumping stations. By the time they resolved the problems, the Japanese advanced through the proposed route. From that time forward the only supplies to China traveled by air.

Nevertheless the experience was invaluable in the development of pipelines.

Military Pipelines

In the summer of 1942 the Quartermaster Corps and the Corps of Engineers reached an agreement that the Engineers would build **and operate** pipelines of a semi permanent nature (which meant anything over three inches diameter). The Quartermaster confined itself to smaller lines and dispensing systems.

To speed construction in a wartime environment the engineers developed a lighter weight pipeline. The sections were joined by rubber couplings that provided a seal by expanding under pressure. These were called Victaulic Couplings after the manufacturer. The rubber couplings also allowed the pipelines to bend slightly.

The engineers also built and operated ship-to-shore pipelines, with the large storage tanks to hold the product as it was unloaded.

Pipelines in Europe

Pipelines were surprisingly successful at moving petroleum in Europe, even in the rugged mountains of Italy.

The only exception came when they were needed most. In August and September 1944 the Allies were advancing as fast as possible. It was just not possible to construct pipelines fast enough to keep up with the advance. Instead the Allies relied on trucks to move the gasoline, and soon offensive came to a halt.

In the haste to support the advancing armies, the Americans placed a lower priority on pipeline construction. Trucks that might have been used to carry pipeline material were instead used to carry gasoline. The Americans sacrificed long-term gains for short-term needs. Pipeline construction resumed after the offensive came to a halt.

PLUTO

Imperial War Museum Collections

Even before the Allies landed in France, the British developed a radical idea of creating a pipeline running through the bottom of the English Channel. This became Operation PLUTO, or Pipeline Under the Ocean. They developed ways of creating a flexible pipeline by creating layers of cable wrapped in a circular fashion and coated to prevent leakage.

The British refined the design through experiments in England and Wales beginning in 1942.

In August 1944 the British laid the first lines from the Isle of Wight (in the English Channel) to the port of Cherbourg (about 70 nautical miles). After some technical difficulties the lines became an effective means to move petroleum to France. A second set of lines later extended through the narrow part of the English Channel.

Altogether PLUTO moved over one million imperial gallons (or 1,200,000 US gallons) of petroleum to France. After the war the techniques developed were used for flexible pipelines in offshore drilling.

Some innovations WWII

The demands of the war motivated other innovations in petroleum management. One was to use collapsible containers as expedient facilities, given the time it took to construct full metal tanks.

These were made from a treated fabric, with a durable (usually metal) frame. In later years collapsible containers became increasingly common for Army petroleum operations.

At this time gasoline remained the dominant petroleum-based fuel, with some kerosene and diesel. Tanks and other major items still operated on gasoline engines (except for a few of the Sherman tanks). Nevertheless at the beginning of the war, different forms of equipment burned different octane levels, complicating the petroleum mission. Working with the Ordnance Department, the Quartermaster Corps developed a standard fuel specification of 80 octane, which was considered high at that time.

Petroleum Laboratories

Once placed in 5-gallon cans or 55-gallon drums gasoline might deteriorate, form gum deposits, or collect water, rust, and impurities. The Army needed a quality surveillance process in both Europe and the Pacific, but the tropical climate of the Pacific was especially hard on gasoline. Sometimes the markings on drums might be eroded off, leaving the owner uncertain of the safety or even the octane rating. Captured enemy fuels required testing before use, both for normal quality control and to protect against sabotage.

Organization varied, but both Europe and the Pacific employed mobile and base section laboratories.

The number of laboratory technicians remained extremely small. From an Army of approximately 8 million, only 300 Soldiers were laboratory technicians. The Quartermaster Corps addressed the training problem by selecting Soldiers with previous training in civilian life.

Korean War

From 1950 to 1953 the American Soldiers fought alongside other forces United Nations forces to defend the Republic of Korea against attempted conquest from North Korea.

Several factors complicated petroleum support. Reductions following World War II had severely diminished the support structure. At that time Korea was an impoverished nation, with very little transportation infrastructure, and rugged mountains. Because this was an international effort, Americans supported small contingents from other nations.

To overcome the initial lack of trained petroleum personnel, the United States persuaded commercial petroleum companies to provide the supervisory personnel and the remaining terminal facilities near Pusan. This cooperation kept the petroleum supply going during this critical phase in the war.

Retail petroleum distribution depended upon the 55-gallon drum.

Army Aviation

Long experimental, the helicopter became practical at the beginning of the Korean War. Army leaders quickly grasped the potential for the helicopter to support ground operations with their ability to land in any field, to fly low and slow, or even to hover as necessary.

During the Korean War they were used for medical evacuation of casualties, observation, transporting small numbers of Soldiers, and other purposes. Their proven usefulness indicated an even grater role in future conflicts.

In 1954 the Army Aviation School opened at Fort Rucker, Alabama, further confirming the permanence of Army aviation.

Helicopters consumed even more fuel than fixed wing aircraft. As they grew in importance, the demands upon the Quartermaster petroleum community increased accordingly.

Quartermaster operates pipelines

In 1955 responsibility for actual operation of petroleum pipelines (but not construction) transferred from the Corps of Engineers to the Quartermaster Corps.

Even before the transfer became official the Quartermaster School began preparing for the change. Petroleum training moved to Fort Lee from New Jersey, and in 1954 Army Reserve units constructed a small pipeline and storage tank for training.

1962 Reorganization

Until 1962 the Office of the Quartermaster General purchased petroleum for the Army, and frequently for other services or nations as well.

In that year the Secretary of Defense directed a reorganization of the Army that eliminated the Quartermaster General, and the heads of the other technical services. (Later the title of Quartermaster General was revived and given to the commandant of the Quartermaster School.)

The Secretary of Defense wanted two new organizations to manage the wholesale logistics. The new Army Materiel Command performed the wholesale management functions within the Army. For common types of supply, the Department of Defense created a new organization known as the Defense Supply Agency (later the Defense Logistics Agency). From that time on, the Defense Supply Agency/ Defense Logistics Agency has purchased petroleum products for all services within DoD.

Cold War

From 1947 to 1989 the America remained in a state of permanent tension with the communist world. For the most part, it did not involve active shooting, but a readiness to engage in combat almost without notice. US forces served overseas on a long term basis, notably in Europe and South Korea.

The Cold War depended upon petroleum. Forces in West Germany and South Korea tended to be armored or mechanized infantry, with a huge demand for petroleum. The ever increasing use of aircraft further contributed to the demands for fuel.

To meet demands the US worked with its European partners in the North Atlantic Treaty Organization (NATO) to construct a pipeline system running through France to West Germany. Another pipeline system in South Korea supported the military efforts there.

Diesel Fuel

Throughout the 1950s, Army ground vehicles typically ran on gasoline. Except for a few World War II model Sherman tanks, even the main battle tank used gasoline.

This that changed in the early 1960s when the Army introduced new lines of equipment that employed diesel engines, including tanks, armored personnel carriers, self propelled artillery, and a wide variety of other tracked vehicles. Even the 2 ½-ton truck switched to multi fuel.

Vietnam

When the United States first entered Vietnam, the nation lacked the petroleum infrastructure so the Army partnered with commercial facilities to share the bulk storage facilities.

Over time the US Army constructed more storage facilities, especially at the huge depots near the coast. Corporate partnerships continued throughout the war.

Pipelines required constant protection from pilferage and enemy action. This meant that pipelines were used near depots and other means were used away from the depots.

The old 55-gallon drum was still used in Vietnam, but not as a principal means of distribution. The Army relied upon tanker trucks or barges to move petroleum whenever possible. In cases of necessity aircraft might move the 500-gallon rubber bladders.

Insatiable Demand

Once again the American consumption of petroleum increased dramatically during the Vietnam War. Helicopters played an unprecedented role in military

operations, with their heavy demand for fuel. By 1968 the Army was moving more than 100 million gallons per month through Vietnam.

Yet even this increase might seem moderate in later years.

Vietnam Problems

Demand was unpredictable during the early years of the war creating chaos in contracting and accounting.

Vietnam lacked any truly safe areas. Even support facilities might be subject to rocket or mortar attacks. Convoy resupply typically included the threat of ambush. Petroleum was an inviting target.

Fire is always a problem in petroleum operations, whether caused by enemy action, American carelessness, or the side effects of pilferage.

Over the course of the war, the United States lost an estimated 5.7 million barrels of petroleum to pilferage. The photo on the left shows a driver making some maintenance checks while the local nationals are helping themselves to some gasoline.

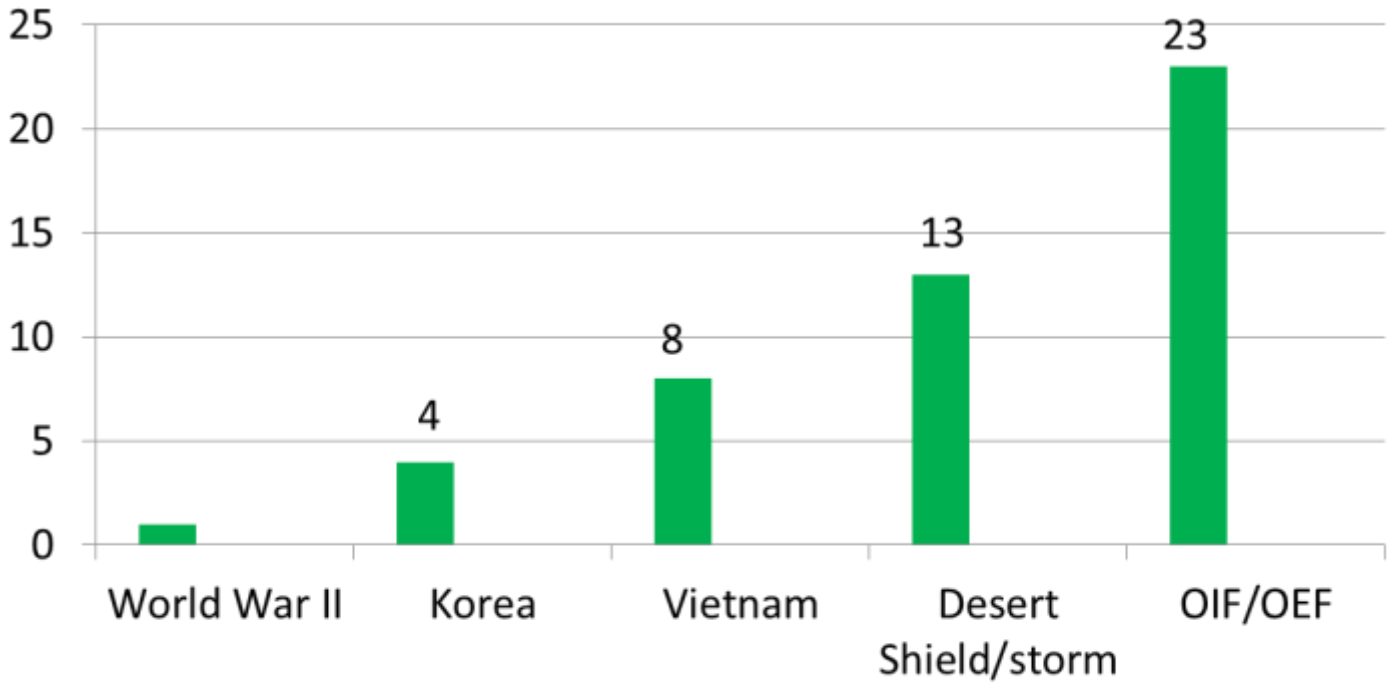
Single Fuel

From the early 1960s through the mid-1980s the Army relied upon a triad of three types of fuel, gasoline for smaller engines, diesel for larger engines and vehicles, and JP4 for aviation. With its low flash point, JP4 was notoriously dangerous.

In the mid-1980s the Army decided to move to a single fuel to ease the logistical considerations. As a result new vehicles were designed to use a fuel approximating kerosene, designated as JP8. The move eased the problem of managing multiple types of fuel, as an added benefit JP8 is safer than JP4.

Nothing is perfect in the Army, and gasoline will appear from time to time. These may come from civilian-type automobiles, contractor support, or other reasons.

Increasing Fuel Consumption



This table shows gallons per Soldier per day. Consumption has continued to go up.

Iraq & Afghanistan

By the time of American operations in Iraq and Afghanistan, petroleum consumption reached previously unimagined levels. On a typical 2007 day in Iraq, the Army consumed about 1.6 million gallons of fuel.

In both Iraq and Afghanistan petroleum support has employed a mixture of American Soldiers and contractors (Americans, local contractors, and third country nationals).

Like Vietnam, Iraq and Afghanistan are counterinsurgency environments, where rear areas and convoys are not truly secure. Petroleum is an attractive target, especially for convoy operations.

Tactical Pipeline

Just prior to commencement of the 2003 operations in Iraq, the Army constructed a 220-mile tactical pipeline using the Inland Petroleum Distribution. Soldiers from the 416th Engineer Command constructed the pipeline. The 49th Quartermaster Group operated the terminal points and the pump stations, in addition to bulk distribution at the far end.

When fully operational the line extended from Camp Virginia, Kuwait all the way to Tallil, Iraq. It could pump up to 600 gallons per minute through its six-inch pipes. Truck units within the group delivered petroleum to units unable to reach the terminal points.

The Future

Until now the Army has seldom considered fuel economy in vehicle design. It has just assumed that the system can provide any fuel needed.

These assumptions have created huge logistical burdens for American forces. Petroleum convoys present another target for adversaries. The current line of thought is to reduce petroleum consumption.

As the Army develops new lines of equipment to replace the present weapons systems, we should expect fuel economy to be a consideration in the design. Of course there is no way to predict the extent of these changes, and it is especially difficult o achieve fuel economy in aviation.

Even as fuel-efficient equipment becomes more common, petroleum will remain a vital commodity for Army operations.